NASA/TM–2015-217544

SIMPL/AVIRIS-NG Greenland 2015

Flight Report

Kelly M. Brunt, Thomas A. Neumann, Thorsten Markus

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

October 2015

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Level of Review: This material has been technically reviewed by technical management

Abstract

In August 2015, NASA conducted a two-aircraft, coordinated campaign based out of Thule Air Base, Greenland, in support of Ice, Cloud, and land Elevation Satellite-2 (ICESat-2) algorithm development. The survey targeted the Greenland Ice Sheet and sea ice in the Arctic Ocean during the summer melt season. The survey was conducted with a photon-counting laser altimeter in one aircraft and an imaging spectrometer in the second aircraft. Ultimately, the mission, *SIMPL/AVIRIS-NG Greenland 2015*, conducted nine coordinated science flights, for a total of 37 flight hours over the ice sheet and sea ice.

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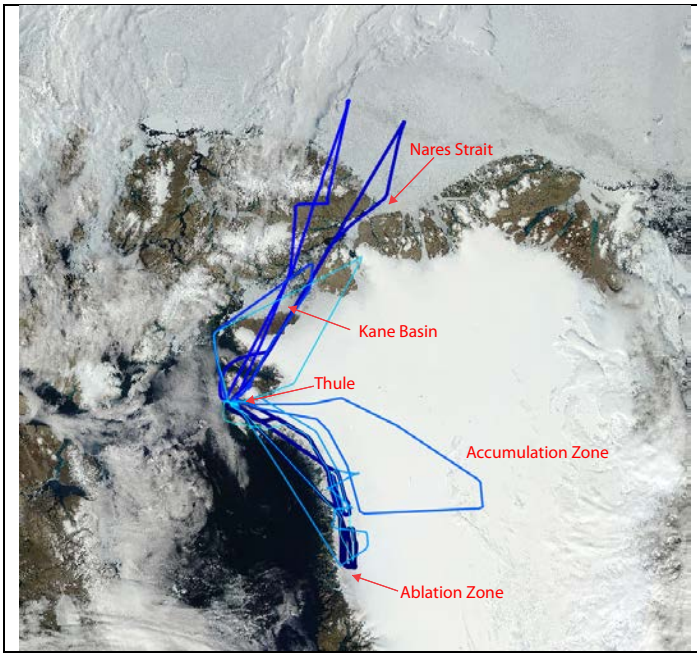
Introduction

In support of Ice, Cloud, and land Elevation Satellite-2 (ICESat-2; Markus et al., 2015), NASA has conducted a series of airborne campaigns primarily to enable the development of ICESat-2 geophysical algorithms prior to launch, which is scheduled for October 2017. ICESat-2 will carry the Advanced Topographic Laser Altimeter System (ATLAS), which will be a six-beam photon-counting laser altimeter using 532-nm wavelength pulses.

Previous airborne lidar campaigns have included a series of flights on high-altitude aircraft using Multiple Altimeter Beam Experimental Lidar (MABEL; McGill et al., 2013). These campaigns surveyed: ice sheets and sea ice in winter conditions (based in Keflaik, Iceland, April 2012; Brunt et al., 2014); glaciers and sea ice in melting conditions (based in Fairbanks, Alaska, July 2014); and vegetation 'leaf-on' conditions (based in Wallops Island, Virginia, September 2012 and Hampton, Virginia, September 2013).

To further refine the ICESat-2 geophysical algorithms, NASA conducted a coordinated airborne campaign designed with the primary goal of addressing how both green- and infrared-wavelength light is affected by water or melt on the ice surface, and with a secondary goal of determining how snow-grain size may affect the propagation of green-wavelength light. These science goals dictated the timing of the mission (August 2015) and the base of operation (Thule Air Base, Greenland). To address the first science goal, NASA Goddard Space Flight Center's (GSFC) Slope Imaging Multi-polarization Photon-counting Lidar (SIMPL) was deployed on a NASA Langley Research Center (LaRC) King Air. To address the second science goal, NASA Jet Propulsion Laboratory's (JPL) Airborne Visible/Infrared Imaging Spectrometer – Next Generation (AVIRIS-NG) was deployed on a King Air operated by Dynamic Aviation. Specific science targets to meet these goals included the dry interior (accumulation zone) of the Greenland Ice Sheet, melt ponds in the ablation zone of the ice sheet, and melting sea ice north of, and within, Nares Strait.

The mission, *SIMPL/AVIRIS-NG Greenland 2015*, ultimately conducted 9 coordinated science flights based out of Thule, for a total of 37 flight hours.



Overview cartoon of SIMPL and AVIRIS-NG coordinated science flights based out of Thule, Greenland. The various shades of blue are used to differentiate the flight lines. Darkest shades occurred earlier in the campaign.

Aircraft

SIMPL was integrated into a NASA Langley Research Center (LaRC) King Air (UC-12B) in July 2015. With the SIMPL instrument configuration, and the need to fly with 2 instrument operators, flights with this aircraft were on the order of 3 to 4 hours; no flight was more than 4.8 hours. The LaRC King Air generally sampled between 2000 and 4500 m above ground level (AGL). Nominal ground speeds (without wind) were about 110 m/s.

NASA Langley Research Center King Air (UC-12B)

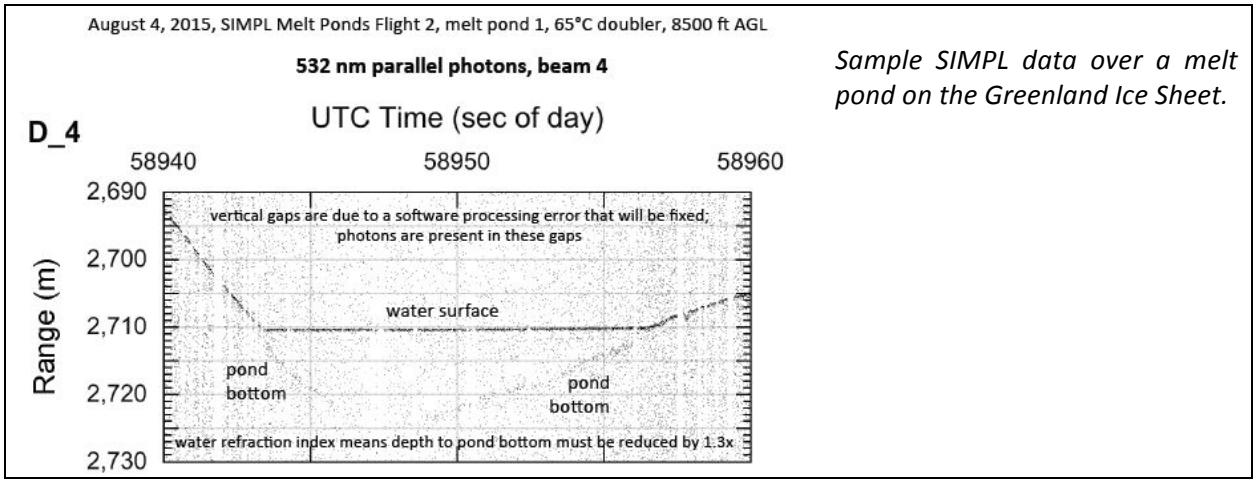
AVIRIS-NG was integrated into a King Air (C-12), operated by Dynamic Aviation, in July 2015. With the AVIRIS-NG configuration (which also required 2 instrument operators), and some other aircraft differences, this aircraft was a bit lighter than the LaRC King Air and thus had a slightly greater range. However, this aircraft mimicked the flight lines of the LaRC King Air and thus never flew more than 4.8 hours on a coordinated science mission. The Dynamic Aviation King Air generally sampled at 7500 m AGL. Nominal ground speeds (without wind) were about 120 m/s.

Dynamic Aviation King Air (C-12)

Instrumentation

The primary instrument on the NASA LaRC King Air was SIMPL. The development of SIMPL (David J. Harding, instrument PI) was initiated under the NASA's Earth Science Technology Office (ESTO) Instrument Incubator Program (IIP). SIMPL is a multi-beam, photon-counting lidar with a high repetition rate and a small field of view (Dabney et al., 2010). SIMPL has 4 beams to simultaneously assess both relative elevation and local slope. At a nominal altitude of 2000 m AGL, SIMPL produces 0.15 – 0.20 m footprints, separated by 5 m, for a total across-track swath of 15 m. While there are 4 beams, SIMPL has a total of 16 channels, as the single laser source is split into 4 beams, and then frequency-doubled to create both 1064 and 532 nm wavelength light, each with both parallel and perpendicular polarization. Fundamental to the 2 primary science goals, the green and near-infrared channels have coincident footprints. For this deployment, SIMPL sampled between 2000 and 4500 m AGL at a nominal ground speed of ~110 m/s.

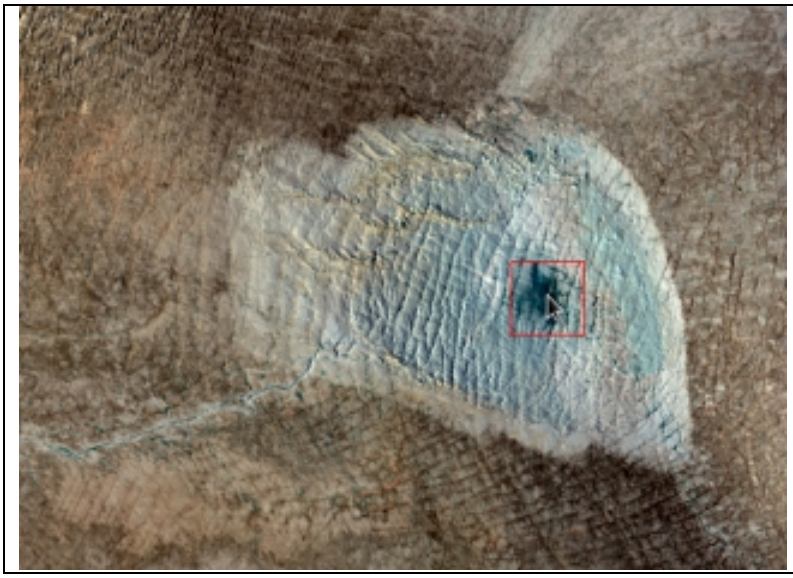
SIMPL had previously been deployed on other aircraft, within the continental United States. In 2009, it was deployed on a NASA Lear-25 (Glenn Research Center) to survey over the Great Lakes and snow-covered regions adjacent to the lakes. It was also flown in conjunction with Eco3D, a 2011 multi-instrument campaign on the NASA Wallops Flight Facility P-3B. That campaign targeted forested regions along the entire eastern seaboard. While much of the SIMPL instrumentation remained the same for the Thule deployment, a major enhancement included the addition of a Transmitter Echo Path (TEP) fiber pick off, which enables the determination of the transmit pulse shape and the determination of relative range biases.



Sample SIMPL data over a melt pond on the Greenland Ice Sheet.

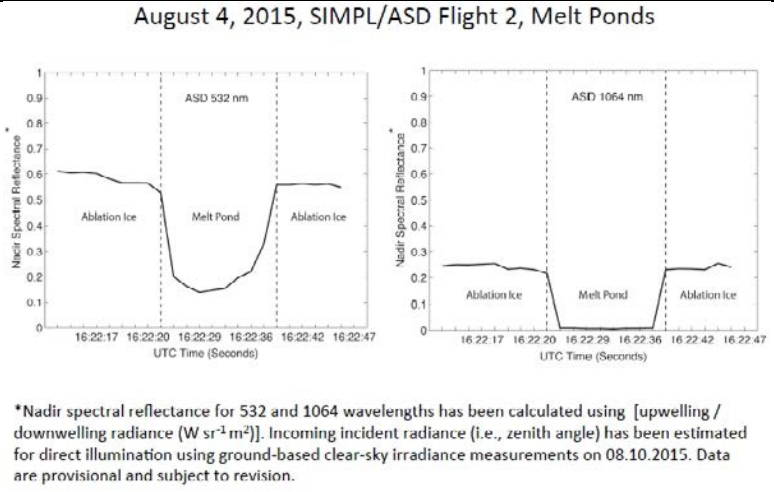
The only instrument on board the Dynamic Aviation King Air was AVIRIS-NG. AVIRIS-NG (Robert O. Green, instrument PI) is a Visible/Short Wave Infrared (VSWIR) imaging spectrometer that measures in a wavelength range of 380 nm – 2510 nm (Hamlin et al., 2011; http://aviris.jpl.nasa.gov/). For this deployment, AVIRIS-NG sampled at approximately 7500 m AGL with a nominal ground speed of ~120 m/s. AVIRIS-NG builds on the heritage of AVIRIS-Classic. Since the 1990's, AVIRIS has been deployed on 4 different aircraft including: the NASA Armstrong Research Center ER-2, the NASA Johnson Space Center WB-57, the Proteus operated by Scaled Composites, and a Twin Otter operated by Twin Otter International. These deployments had been limited to the United States and sub-Arctic Canada.

Therefore, this deployment represented the first integration of AVIRIS-NG into a King Air, and the first surveys over the Arctic.



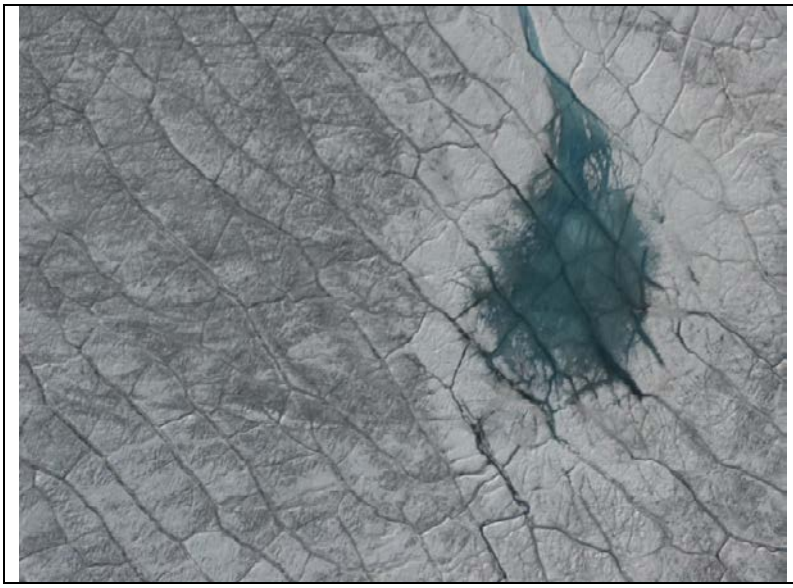
Sample AVIRIS-NG image over a drained melt pond on the Greenland Ice Sheet.

Ancillary instrumentation on the NASA LaRC King Air included a pair of full-range, profiling spectrometers (Christopher Crawford, ASD instrument lead). The primary profiler was a downward-looking ASD FieldSpec Pro to retrieve surface radiance (W $sr^{-1}/m^2/nm^{-1}$). The FieldSpec Pro had a 1-degree fore optic and generated a ~45 m surface footprint (at a nominal altitude of 2000 m AGL), which was spatially coincident with the SIMPL 4-beam swath. The second profiler was upward-looking ASD FieldSpec 3 to retrieve total sky irradiance (W m^2/nm^{-1}), intended for the calibration of the downward-looking ASD. The FieldSpec 3 had a remote cosine receptor (RCR) fore optic. Both ASD instruments have a 350 – 2500 nm spectral range and were calibrated to a National Institute of Standards and Technology (NIST) traceable lamp at NASA Goddard Space Flight Center, both prior to and post mission completion. The justification for deploying these instruments aboard the SIMPL aircraft was to obtain spectral information, and ultimately snow-grain size variations, in the event that synchronous data from AVIRIS-NG were not available.



Sample ASD data over a melt pond on the Greenland Ice Sheet.

A nadir-looking frame camera was also deployed on the NASA LaRC King Air. The camera was intended to provide ground validation of returned surface types, such as sea ice versus leads within the sea ice, and to provide a first-order assessment of the cloud state between SIMPL and the surface. Camera images are approximately 280 by 210 m at a nominal altitude of 2000 m AGL.



Sample nadir-looking frame camera image of a melt pond on the Greenland Ice Sheet. Camera images are approximately 280 by 210 m at a nominal altitude of 2000 m AGL.

Finally, an Applanix positioning and inertial system (POS AV 610) was also deployed on the NASA LaRC King Air. This system provided post-processed position accuracy between 0.05 – 0.30 m and angular accuracy (pitch, roll, and heading) between 0.0025 – 0.0050°.

Discussion and Conclusions

The appendix of this document includes summaries associated with each individual mission flight. Details captured in these summaries include maps of flight tracks, comments about the instrumentation, and comments about weather. This document focuses on SIMPL, as the primary instrument. As such, it includes flight summaries for all SIMPL flights, including instrument check flights in Virginia and uncoordinated calibration flights in Thule. This document does not include flight summaries associated with the AVIRIS-NG check flights based in Virginia.

Two SIMPL instrument checkout flights were conducted based out of Hampton, Virginia, and included targets over vegetated regions, lakes, Chesapeake Bay, and over the open ocean. Due to LaRC King Air configuration and the required (high) altitudes to expedite the flights from Virginia to Thule, Greenland, SIMPL data were not collected on the ferry flights.

Similar to SIMPL, AVIRIS-NG also had 2 checkout flights, based out of Bridgewater, Virginia. Since the AVIRIS-NG instrument operators deployed to Thule with the aircraft, imaging spectroscopy data were collected on part of the ferry from Virginia to Thule, Greenland. However, data were not collected on the southbound ferry, as AVIRIS-NG was shut down, including the cryocoolers that maintain instrument operational temperature, and brought up to ambient temperature, prior to the departure south.

Once both aircraft arrived in Thule, coordinated flights commenced. Since SIMPL was the primary instrument, the NASA LaRC King Air took off first on every mission. The Dynamic Aviation aircraft took off and landed within 15 minutes of the primary aircraft on every mission. Gaps in the data associated with any instrument, on either aircraft, were brief and therefore did not necessitate real-time decisions on either aircraft returning to base. In general, aircraft operations associated with the coordinated surveying of science targets went very smoothly.

Both the primary (SIMPL) and secondary (AVIRIS-NG) instruments, and some of the ancillary instrument, require clear sky conditions. Further, the remote nature of Thule Air Base makes flight operations extremely challenging. This deployment experienced difficult weather conditions during the first week of operations, but experienced very favorable weather during the second week. The flight summaries make note of the general weather conditions. Additionally, the flight tracks are plotted on the MODIS Rapid Response Daily mosaic of the Arctic to provide a snapshot of the general cloud state (http://lance-modis.eosdis.nasa.gov/imagery/subsets/?project=arctic).

SIMPL signal strength can be controlled via a few different methods, one of which is by changing flight altitude (AGL). These values were changed throughout the deployment based on previous results and surface type (see table below). These values are also included in the individual flight summaries in the Appendix.

Flight Date	Water	Accumulation Zone	Ablation Zone	Sea Ice
07/21/2015	8500	N/A	N/A	N/A
07/23/2015	8500	N/A	N/A	N/A
07/30/2015	7500	7500	7500	N/A
08/03/2015	7500	13500	13500	N/A
08/04/2015	7500	8500	8500	N/A
08/07/2015	7500	N/A	N/A	6500
08/10/2015	7500	N/A	N/A	6500
08/11/2015	7500	N/A	N/A	6500
08/12/2015	7500	8500	7500	N/A
08/13/2015	7500	8500	7500	N/A
08/14/2015	7500	10500	10500	9500
08/17/2015	6500	9500	9500	N/A

Table of requested survey altitudes, for various surface types, for each SIMPL flight (in ft AGL, for consistency with the flight summaries in the Appendix).

For land ice surveys, to address the science goals, a major flight objective was to acquire SIMPL and AVIRIS-NG data from the ablation zone, where the surface was melted, to the ice-sheet interior, where the surface was relatively dry. This was accomplished on 2 flights: 8/12/2015, which surveyed the highest and most inland ice of this campaign, and 8/17/2015, where flight lines perpendicular to the coastline extended into the accumulation zone.

Another major flight objective was to acquire SIMPL data over melt ponds. This was easily accomplished on a series of flights that were parallel to the northwest coast of Greenland (initial flights on 8/3/2015

and 8/4/2015; follow-up flight on 8/17/2015). The NASA LaRC aircraft deviated from the planned flight paths to sample these; communication with the Dynamic Aviation aircraft ensured that AVIRIS-NG continuously sampled spatially coincident data. A repeated survey of some of the coast-parallel lines on 8/17/2015 indicates that some of the melt ponds had started to freeze over.

The sea ice proved to be challenging to survey. This was primarily due to large-scale, upper-level cloud systems in the Arctic and low-level fog associated with open leads north of Nares Strait. Further, at the northern ends of the sea ice runs in the Arctic, on both 8/7/2015 and 8/10/2015, it appears that the nadir port glass fogged up while surveying north of Nares Strait. Ultimately, we had success in surveying pack ice in Kane Basin, in the southern portion of Nares Strait.

All SIMPL flights included pitch and roll maneuvers; the times of these are indicated in the individual flight summaries. Many SIMPL flights, and a few AVIRIS-NG flights, also included passes over the ramp in front of the hangar space associated with this mission. NASA's Operation IceBridge Mission has previously conducted ground-based GPS surveys of the ramp. The differentially post-processed ground data has an RMS < 5 cm and can be used to assess SIMPL precision and accuracy. During the 8/14/2015 flight, both aircraft made several passes over the ramp while an ASD FieldSpec 3 was making ground-based measurements. These data can be used to calibrate and validate both AVIRIS-NG and the nadir-looking ASD FieldSpec Pro.

All datasets associated with *SIMPL/AVIRIS-NG Greenland 2015* (SIMPL, AVIRIS-NG, ASD, and the camera) are to be made available on the ICESat-2 website (http://icesat.gsfc.nasa.gov/icesat2/data.php).

Acknowledgements
We thank the instrument field teams: Dave Harding, Susan Valett, Beth Timmons, Phil Dabney, Tony Yu, and Kurt Rush, with SIMPL; Rob Green, Peter Sullivan, and Marco Hernandez, with AVIRIS-NG; and Chris Crawford, with the ASDs. We thank the aircraft pilots: Rick Yasky and Mike Wusk, with LaRC; and Aaron Mingle and Merlin Yoder, with Dynamic Aviation. We thank the aircraft field crew: Andy Haynes, Dave Perez, and Sean DeRubba. We thank Kaitlin Walsh for field data assistance. And we thank Dennis Gearhart and James Jacobson (NASA ARC) and Kyle Krabill (NASA WFF) for Applanix support.

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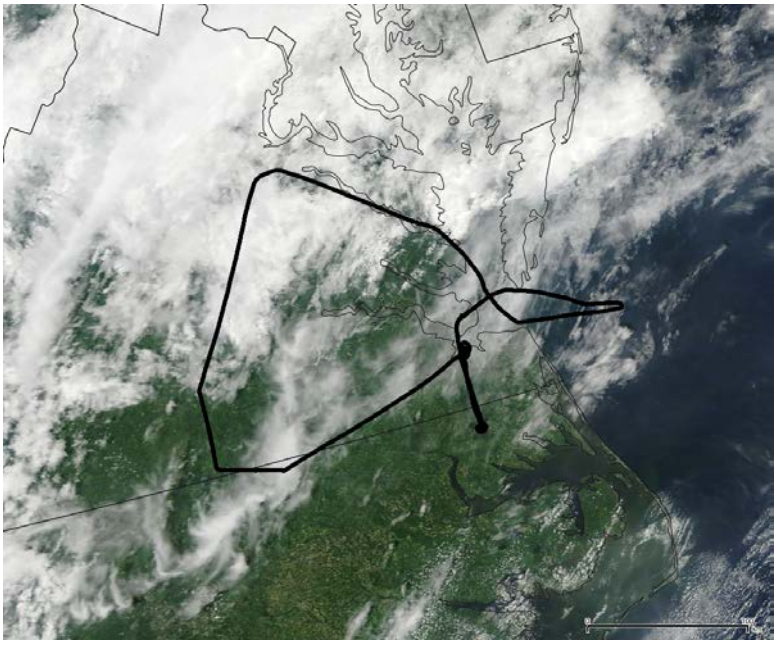
Appendix

The appendix of this document includes summaries associated with each individual mission flight. Details captured in these summaries include maps of flight tracks, comments about the instrumentation, and comments about weather. This document focuses on SIMPL, as the primary instrument. As such, it includes flight summaries for all SIMPL flights, including instrument check flights in Virginia and uncoordinated calibration flights in Thule. This document does not include flight summaries associated with the AVIRIS-NG check flights based in Virginia.

07/21/2015

Mission: LaRC KING AIR ONLY (VA) 'Instrument Check Flight (ICF)'



Weather: clouds over Corbin; major storms in the northern part of Chesapeake Bay

Instruments: SIMPL, Applanix, ASDs, nadir camera:
ASD integrated but not run; Applanix had a hiccup, but fine; large spot on lense of camera

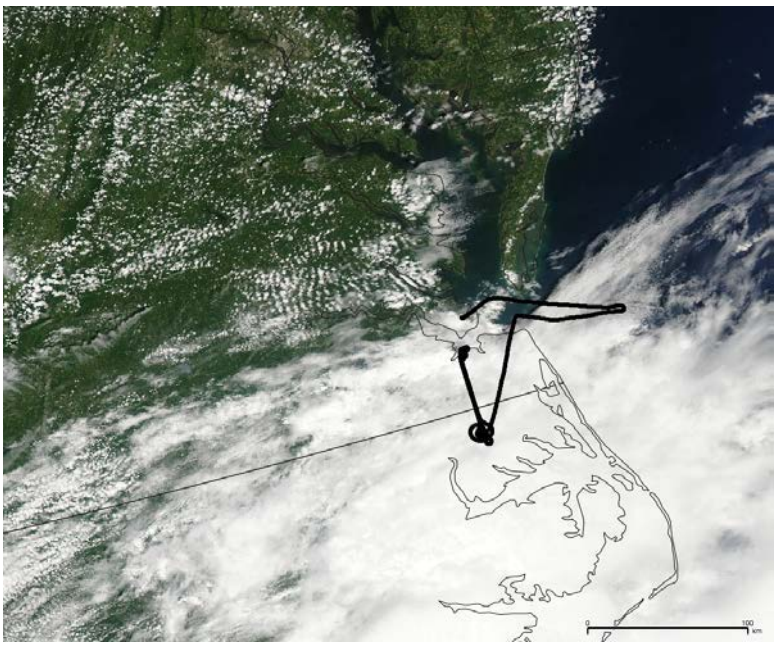
Day flight
NASA Langley UC-12B (2.8 hours)
Requested SIMPL sample altitude: **8,500 ft AGL (with variation for calibration)**

SIMPL points of interest:

Time (UTC)	Description
13:30	Applanix on
14:15	Variable altitudes AGL Start
15:00	Variable altitudes AGL End
16:25	P/R maneuver
16:41	P/R maneuver
17:15	Applanix off

07/23/2015

Mission: LaRC KING AIR ONLY (VA) 'Second Check Flight'



Weather: Generally pretty good

Instruments: SIMPL, Applanix, ASDs, nadir camera:
ASD integrated but not run; camera images slightly saturated; SIMPL had 1 blue screen/restart; Applanix had a hiccup at the beginning of flight; aircraft had 1 load shed

Day flight
NASA Langley UC-12B (2.0 hours)
Requested SIMPL sample altitude: **8,500 ft AGL (with variation for calibration)**

SIMPL points of interest:

Time (UTC)	Description
13:15	Applanix on (issues at startup)
13:30	Variable altitudes AGL Start
14:45	Variable altitudes AGL End
14:55	P/R maneuver
15:02	P/R maneuver
15:45	Applanix off

07/29/2015

Mission: LaRC KING AIR ONLY (Thule) 'ASD Calibration Flight'

Weather: Generally pretty good; clouds building

Instruments: SIMPL, Applanix, ASDs, nadir camera:
SIMPL not run (therefore, no P/R); camera saturated over ice; dark elsewhere; raw camera images are named using EDT, not UTC; Applanix had a few hiccups

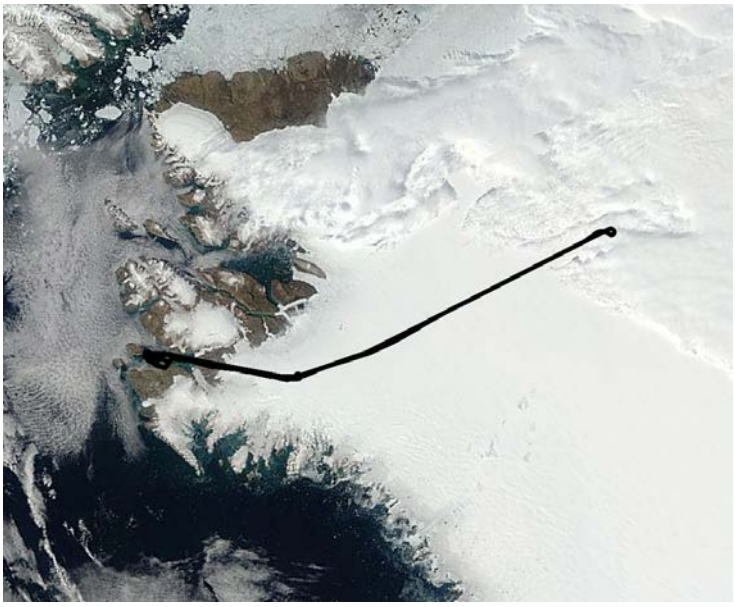
Day flight
NASA Langley UC-12B (2.6 hours)
Requested SIMPL sample altitude: **7,500 ft AGL throughout**

SIMPL points of interest:

Time (UTC)	Description
14:30	Applanix on
17:45	Applanix off

07/30/2015

Mission: LaRC KING AIR ONLY (Thule) 'SIMPL Calibration Flight'



Weather: Generally pretty good

Instruments: SIMPL, Applanix, ASDs, nadir camera:
continued gain issues in camera (dark images); large spot on lens; raw camera images are named using EDT, not UTC; hard time bringing ASDs online

Day flight
NASA Langley UC-12B (3.8 hours)
Requested SIMPL sample altitude: **7,500 ft AGL throughout**

SIMPL points of interest:

Time (UTC)	Description
11:00	Applanix on
13:56	P/R maneuver at 7,500 ft AGL
14:28	P/R maneuver at 7,500 ft AGL
15:45	Applanix off

07/29/2015 – 07/31/2015

Mission: DYNAMIC AVIATION KING AIR ONLY 'Ferry Flights'

Four legs:
1) Bridgewater, VA to Burlington, VT (7/29/15);
2) Burlington, VT to Goose Bay, Laborador (7/29/15);
3) Goose Bay, Laborador to Sondrestrom, Greenland (7/30/15); and
4) Sondrestrom, Greenland to Thule, Greenland (7/31/15)

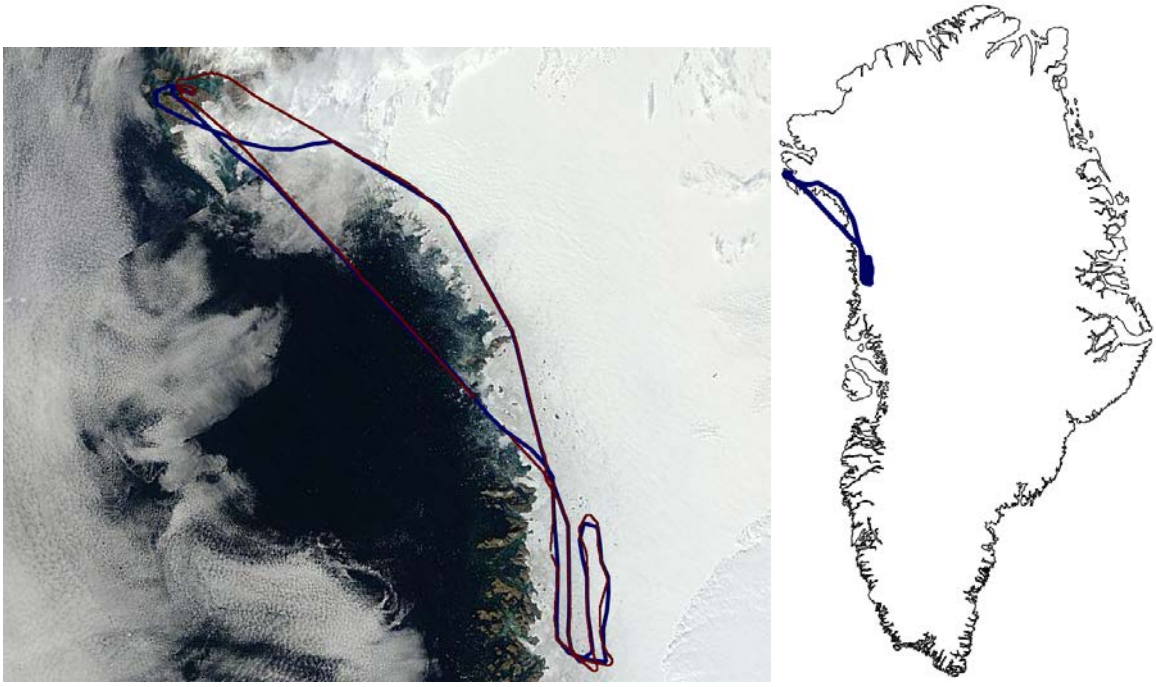
Weather: Beautiful flight from Sondrestrom to Thule

Instruments: AVIRIS-NG:
AVIRIS-NG collected ~2 hrs of data from Sondrestrom to Thule.

Day flights
Dynamic Aviation C-12
KVBW to KBVT: 2.3 hours
KBVT to CYYR: 3.6 hours
CCYR to BGSF: 4.1 hours
BGSF to BGTL: 3.2 hours

08/03/2015

Mission: SIMPL & AVIRIS-NG COORDINATED 'Coast Parallel Melt Ponds South'



Red track: LaRC UC-12B; Blue track: Dynamic Aviation C-12
Weather: light clouds over northern stretch; cloud-free over melt-pond region

Instruments: SIMPL, AVIRIS-NG; Applanix, ASDs, nadir camera:
AVIRIS-NG had icing on port glass; ASDs had some saturation
Best flight for non-frozen-over melt ponds.

Day flight
Dynamic Aviation C-12 (3.9 hours)
Requested AVIRIS-NG sample altitude: 25,000 ft AGL

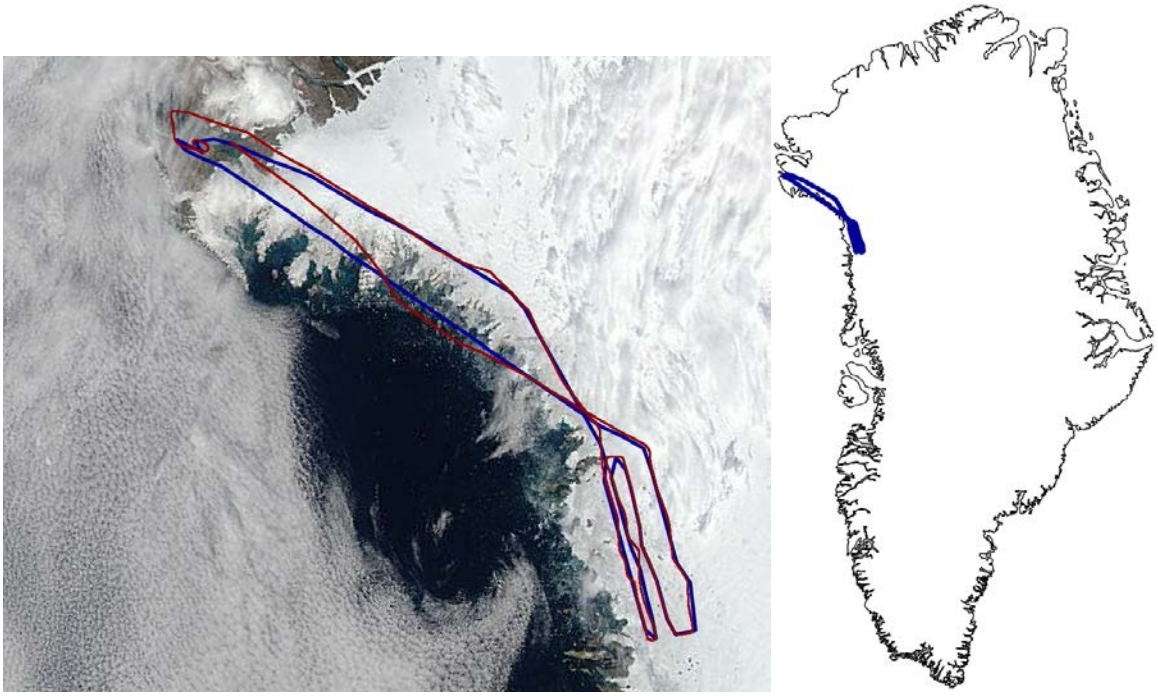
NASA Langley UC-12B (3.9 hours)
Requested SIMPL sample altitude: **13,500 ft AGL over ice sheet;**
7,500 ft AGL over water

SIMPL points of interest:

Time (UTC)	Description
11:30	Applanix on
12:25	P/R maneuver (high)
15:33	P/R maneuver at 7,500 ft AGL
16:15	Applanix off

08/04/2015

Mission: **SIMPL & AVIRIS-NG COORDINATED** 'Coast Parallel Melt Ponds North'



Red track: LaRC UC-12B; Blue track: Dynamic Aviation C-12
Weather: light clouds over central stretch; cloud-free over melt-pond region

Instruments: SIMPL, AVIRIS-NG; Applanix, ASDs, nadir camera:
ASDs had some saturation

Day flight
Dynamic Aviation C-12 (3.2 hours)
Requested AVIRIS-NG sample altitude: 25,000 ft AGL

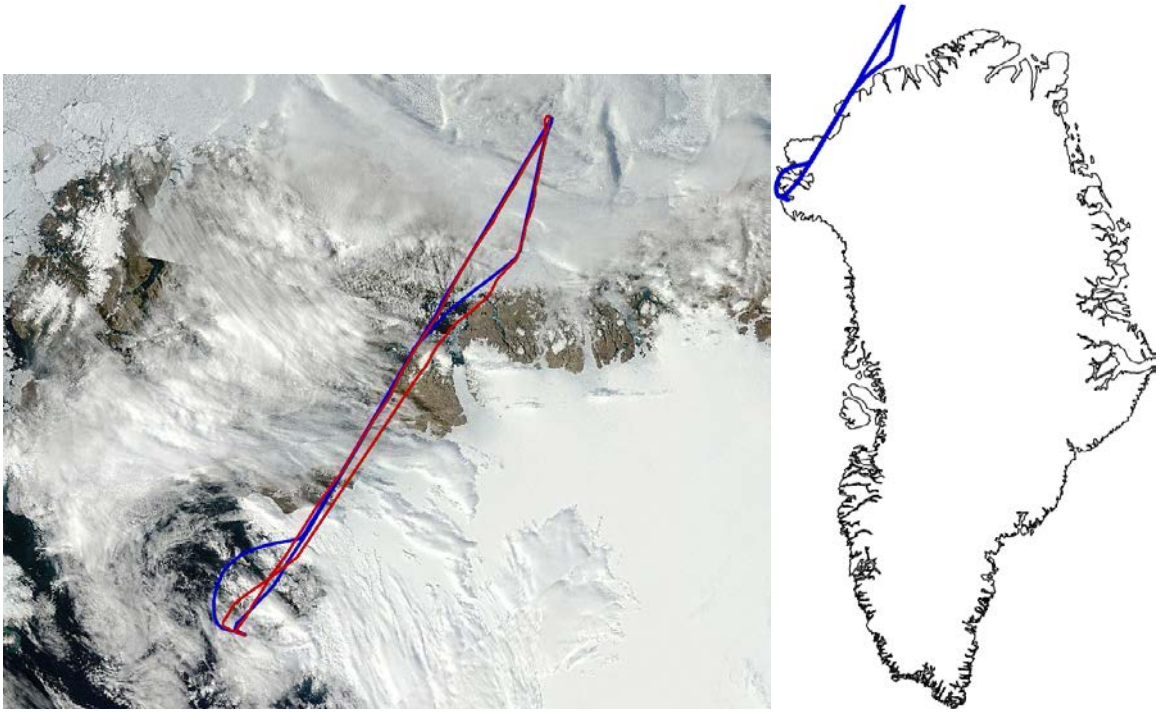
NASA Langley UC-12B (3.2 hours)
Coordinated with AVIRIS-NG
Requested SIMPL sample altitude: **8,500 ft AGL over ice sheet;**
7,500 ft AGL over water

SIMPL points of interest:

Time (UTC)	Description
15:00	Applanix on
15:48	P/R maneuver at 17,500 ft AGL
18:20	P/R maneuver at 7,500 ft AGL
19:00	Applanix on=ff

08/07/2015

Mission: SIMPL & AVIRIS-NG COORDINATED 'Sea Ice 1'



Red track: LaRC UC-12B; Blue track: Dynamic Aviation C-12
Weather: very cloudy the entire way; high deck of thick clouds; low deck of fog/thin clouds; AVIRIS-NG collected no data due to clouds

Instruments: SIMPL, AVIRIS-NG; Applanix, ASDs, nadir camera:
camera had a hiccup at the start of the flight; camera imagery also suggests that either the camera lens or the port glass was fogged after coming low to sample (prior to 14:20); up-looking ASD had issues

Day flight
Dynamic Aviation C-12 (4.8 hours)
Requested AVIRIS-NG sample altitude: 25,000 ft AGL

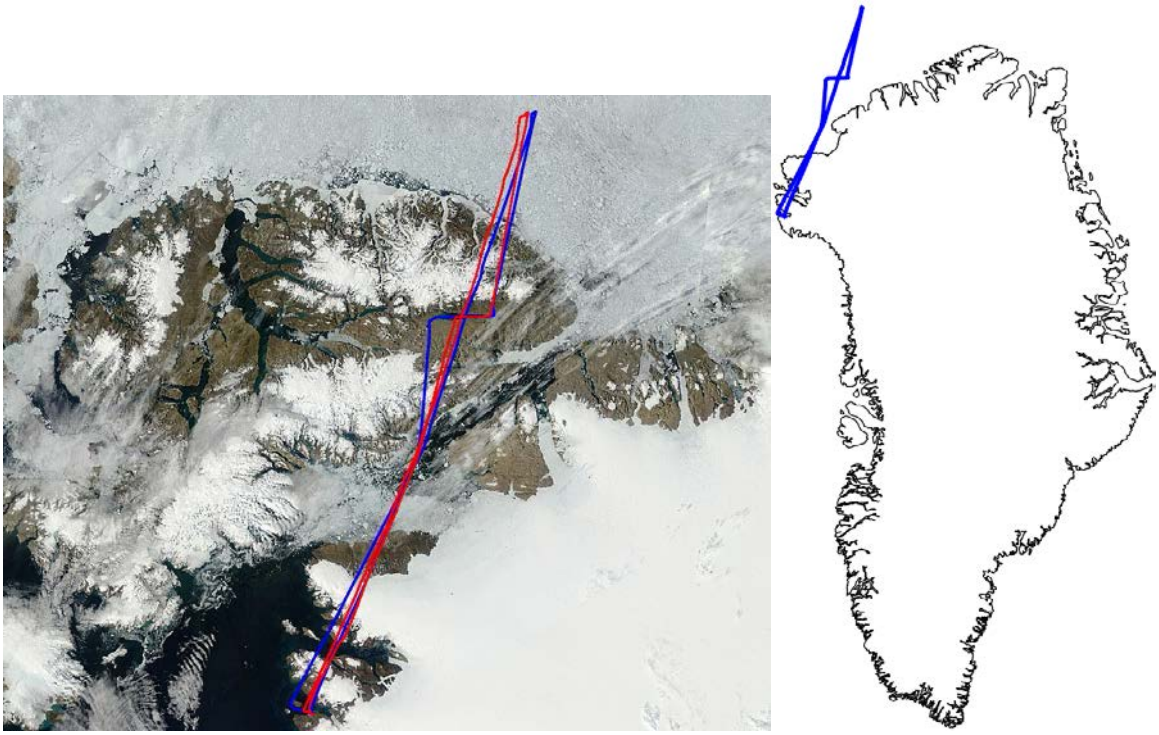
NASA Langley UC-12B (4.8 hours)
Requested SIMPL sample altitude: **6,500 ft AGL over sea ice**

SIMPL points of interest:

Time (UTC)	Description
11:15	Applanix on
14:47	P/R maneuver at 8,000 ft AGL
16:45	Applanix off

08/10/2015

Mission: SIMPL & AVIRIS-NG COORDINATED 'Sea Ice 2'



Red track: LaRC UC-12B; Blue track: Dynamic Aviation C-12
Weather: low ground fog that may have compromised SIMPL surface return; Lake Hazen had melted out

Instruments: SIMPL, AVIRIS-NG; Applanix, ASDs, nadir camera:
cameras filled the disk; camera saturated over sea ice up north; camera imagery also suggests that either the camera lens or the port glass was fogged after coming low to sample (14:10 to 14:25; most obvious that it is on the glass during 14:20)

Day flight
Dynamic Aviation C-12 (4.7 hours)
Requested AVIRIS-NG sample altitude: 25,000 ft AGL

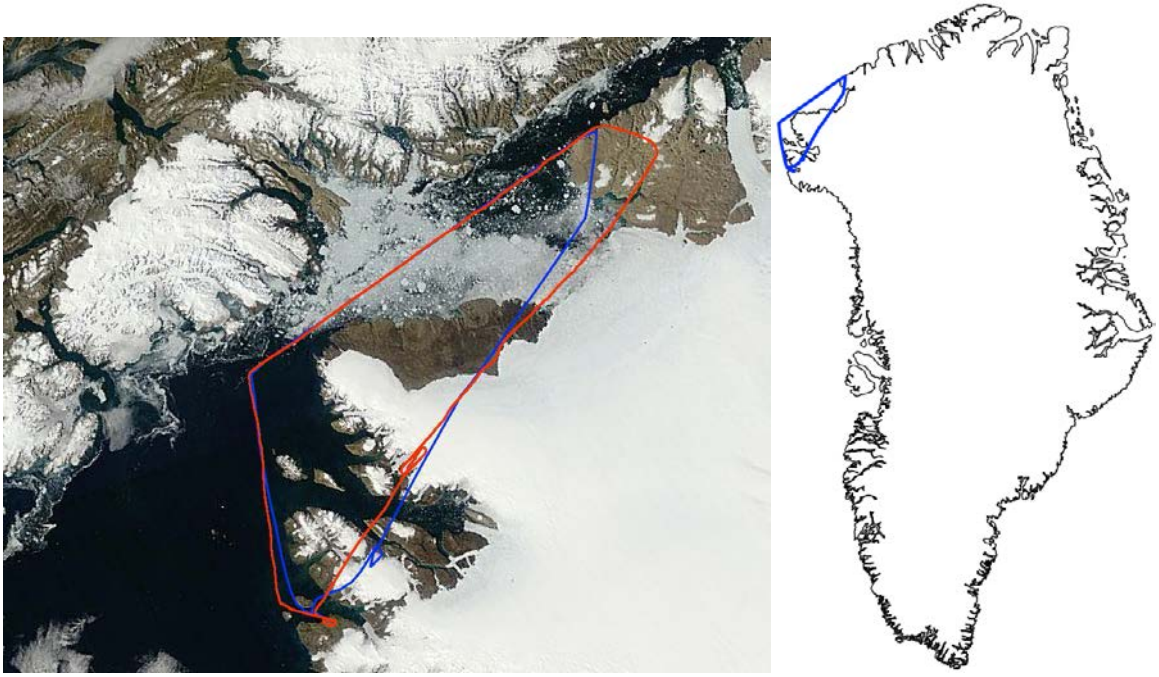
NASA Langley UC-12B (4.7 hours)
Requested SIMPL sample altitude: **6,500 ft AGL over sea ice;**
7,500 ft AGL over water (including Lake Hazen)

SIMPL points of interest:

Time (UTC)	Description
11:30	Applanix on
14:09	P/R maneuver at 6,500 ft AGL
16:45	Applanix off

08/11/2015

Mission: SIMPL & AVIRIS-NG COORDINATED 'Sea Ice, Southern Nares Strait'



Red track: LaRC UC-12B; Blue track: Dynamic Aviation C-12
Weather: clear

Instruments: SIMPL, AVIRIS-NG; Applanix, ASDs, nadir camera:
NASA Langley UC-12B had HF radio issues; cut flight plan north a bit short
Dynamic Aviation flew a second calibration mission, with passes over the runway ramp (16:50 – 17:40 UTC)

Day flight
Dynamic Aviation C-12 (3.2 hours)
Requested AVIRIS-NG sample altitude: 25,000 ft AGL

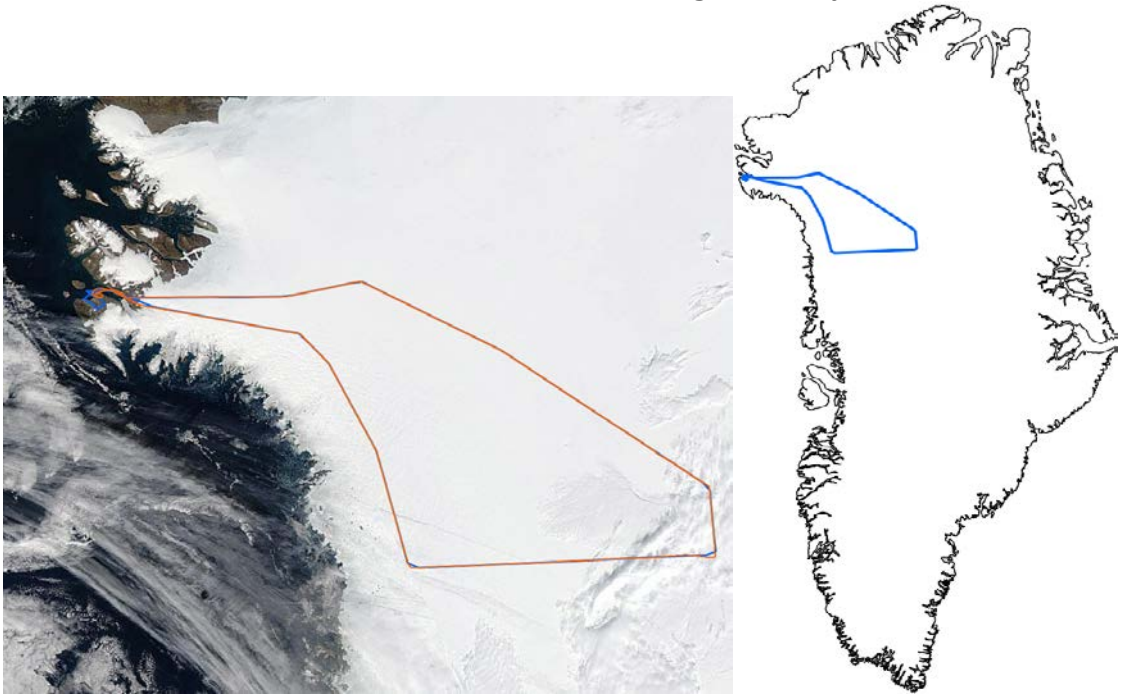
NASA Langley UC-12B (3.2 hours)
Requested SIMPL sample altitude: **6,500 ft AGL over sea ice**

SIMPL points of interest:

Time (UTC)	Description
12:00	Applanix on
14:02	P/R maneuver at 6,500 ft AGL
16:00	Applanix off

08/12/2015

Mission: SIMPL & AVIRIS-NG COORDINATED 'High-and-Dry'



Red track: LaRC UC-12B; Blue track: Dynamic Aviation C-12
Weather: 'Great Weather'; AVIRIS-NG experienced high clouds at southern extent of inland flight line (MODIS image above is from 8/13/2015)

Instruments: SIMPL, AVIRIS-NG; Applanix, ASDs, nadir camera:
Applanix only logged to USB; up-looking ASD had issues; camera imagery had gaps
Best flight for coordinated (SIMPL and AVIRIS-NG) data from ablation zone to accumulation zone.

Day flight
Dynamic Aviation C-12 (4.4 hours; Rob Green flew on this mission)
Requested AVIRIS-NG sample altitude: 25,000 ft AGL

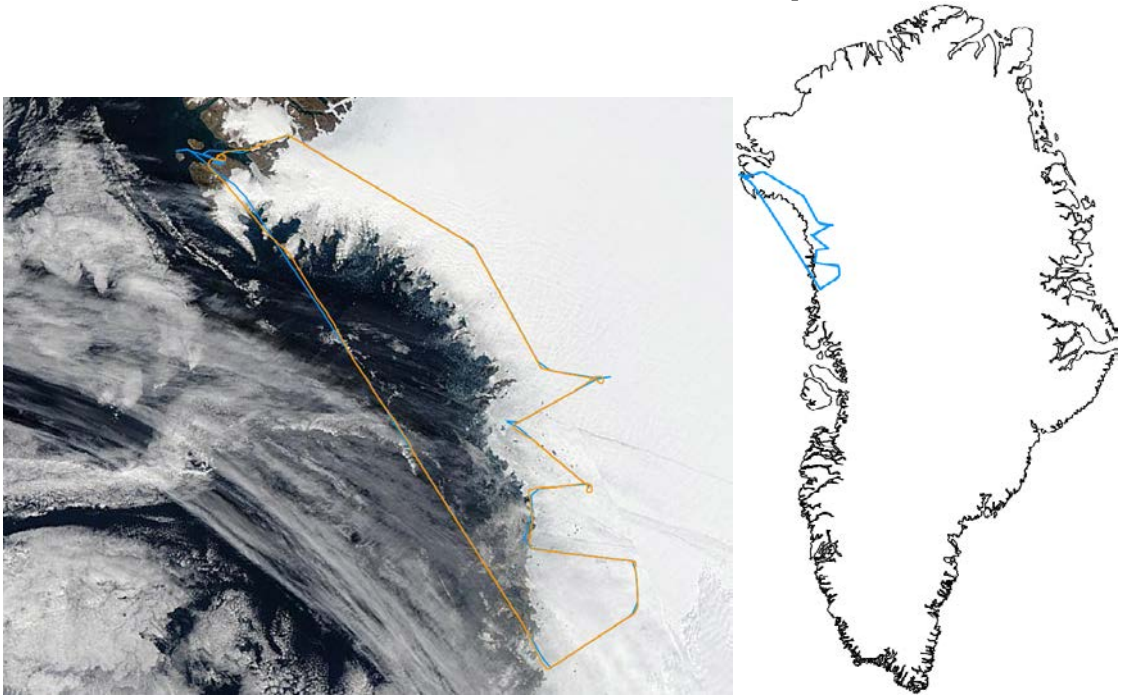
NASA Langley UC-12B (4.4 hours)
Requested SIMPL sample altitude: **7,500 ft AGL over the ice sheet (ablation zone); 8,500 ft AGL over the ice sheet (accumulation); 7,500 ft AGL over water**

SIMPL points of interest:

Time (UTC)	Description
11:15	Applanix on
16:09	P/R maneuver at 7,500 ft AGL
16:45	Applanix off

08/13/2015

Mission: SIMPL & AVIRIS-NG COORDINATED 'Coast Perpendicular'



Red track: LaRC UC-12B; Blue track: Dynamic Aviation C-12
Weather: generally clear; southernmost line is probably a little cloudy

Instruments: SIMPL, AVIRIS-NG; Applanix, ASDs, nadir camera:
down-looking ASD saturated

Day flight
Dynamic Aviation C-12 (4.1 hours)
Requested AVIRIS-NG sample altitude: 25,000 ft AGL

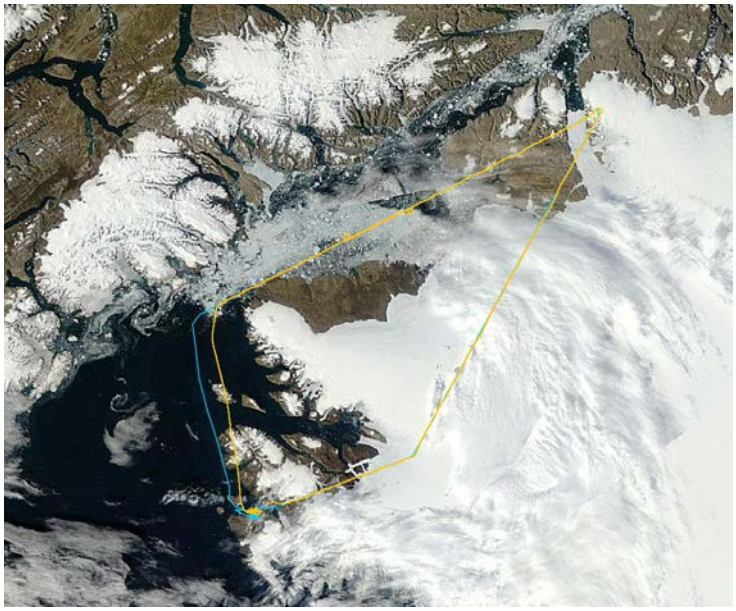
NASA Langley UC-12B (4.1 hours)
Requested SIMPL sample altitude: **7,500 ft AGL over the ice sheet (ablation zone); 8,500 ft AGL over the ice sheet (accumulation); 7,500 ft AGL over water**

SIMPL points of interest:

Time (UTC)	Description
11:45	Applanix on
15:42	P/R maneuver at 7,500 ft AGL
16:15	Applanix off

08/14/2015

Mission: SIMPL & AVIRIS-NG COORDINATED 'ICESat-2 Line and Sea Ice, Southern Nares Strait'



Red track: LaRC UC-12B; Blue track: Dynamic Aviation C-12
Weather: generally clear; shadow on ICESat-2 (and IceBridge) line

Instruments: SIMPL, AVIRIS-NG; Applanix, ASDs, nadir camera:
down-looking ASD saturated over sea ice; Applanix logged only to internal storage and filled disk; ASD and AVIRIS-NG calibration flight; multiple passes over Thule runway ramp; Rob Green and Chris Crawford on ramp with field ASD Best flight for pack ice in Nares Strait.

Day flight
Dynamic Aviation C-12 (4.0 hours)
Requested AVIRIS-NG sample altitude: 25,000 ft AGL

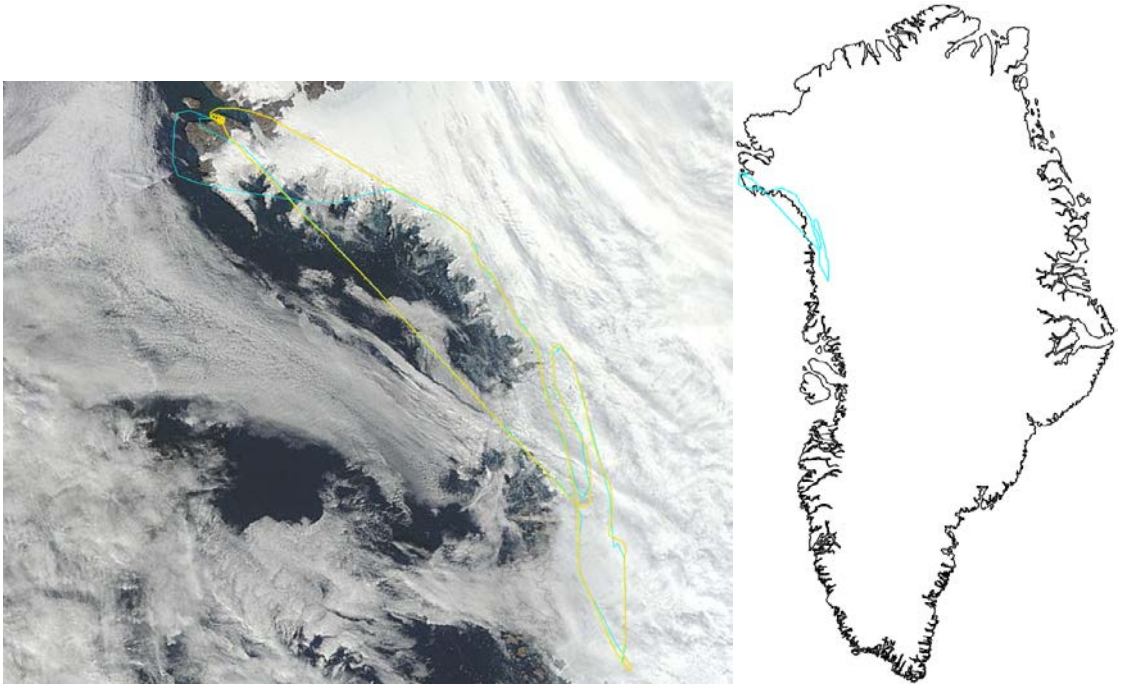
NASA Langley UC-12B (4.0 hours)
Requested SIMPL sample altitude: **10,500 ft AGL over the ice sheet; 9,500 ft AGL over sea ice**

SIMPL points of interest:

Time (UTC)	Description
11:30	Applanix on
12:39	P/R maneuver on ice sheet at 12,000 ft AGL
13:31	P/R maneuver over water at 9,500 ft AGL
13:45	Variable altitudes AGL Start
14:15	Variable altitudes AGL End
16:00	Applanix off

08/17/2015

Mission: SIMPL & AVIRIS-NG COORDINATED 'Coast Parallel; Frozen Melt Ponds'



Weather: generally a bit cloudy, especially at southern extent; flight was changed en route to lines farther north; melt ponds were starting to freeze over

Instruments: SIMPL, AVIRIS-NG; Applanix, ASDs, nadir camera:
all OK; Best flight for frozen-over melt ponds.

Day flight
Dynamic Aviation C-12 (3.9 hours; Rob Green flew on this mission)
Requested AVIRIS-NG sample altitude: 25,000 ft AGL

NASA Langley UC-12B (3.9 hours)
Requested SIMPL sample altitude: **9,500 ft AGL over the ice sheet; 6,500 ft AGL over water**

SIMPL points of interest:

Time (UTC)	Description
11:15	Applanix on
15:05	P/R maneuver at 6,500 ft AGL
15:45	Applanix off